RP 202 Grease Lubricated Bearing Maintenance

The following recommended practice (RP) is subject to the disclaimer at the front of this manual. It is important that users read the disclaimer before considering adoption of any portion of this recommended practice.

This recommended practice was prepared by a committee of the AWEA Operations and Maintenance (O&M) Committee.

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Purpose and Scope

The scope of “Grease Lubricated Bearing Maintenance” addresses the common maintenance issues related to lubrication of generator bearings and a basic trouble shooting guide to help with service and repair decisions.

Introduction

Conventional utility scale wind turbine generators range from 500 kW to > 3 MW in production capabilities. Most of these units use grease lubricated anti-friction ball bearings that require some type of replenishment on a regular basis on both the drive and non-drive ends of the machine. Often, lubrication supply devices are utilized to partially automate the process, but monitoring and adjustments are required even with these automated systems. A few turbine designs have generators directly mounted to the gearbox and will only have one, non-drive end bearing to be maintained as the drive end bearing is integral to the gearbox lubrication system. Whereas alignment issues are simplified with these direct coupled machines, assuring proper lubrication is still a key element in good maintenance procedures. Alignment and vibration also contribute to premature bearing failures and those issues will be addressed in separate recommended practice documents. Regardless of design, it is critical that the proper amount of lubricant is used; both too little and too much grease will dramatically shorten the life of the bearing.

The proper choice of lubricant is normally specified by the generator manufacturer, but a general overview is included in this recommended practice for informational purposes only. Please refer to industry standard documents for more details.

Direct drive machines use generators that are integral to the main shaft of the wind turbine and the lubrication of those main bearings are discussed in other recommended practices.

Grease Lubricated Bearing Maintenance

1. Overview of Grease Lubricated Bearings

Lubricating greases usually consist of mineral or synthetic oil suspended in a thickener, with the oil typically making up 75% or more of the grease volume. Chemicals (additives) are added to the grease to achieve or enhance certain performance properties. As a result of having a thickener package, grease is more easily retained in the bearing arrangement, particularly where shafts are inclined or vertical. Grease also helps to seal bearings against solid particulate and moisture contamination. Excessive amounts of grease will cause the operating temperature in the bearing to rise rapidly, particularly when running at high speeds. As a general rule for grease lubricated bearings, the bearing should be completely filled with grease prior to start-up but the free space in the housing should only be partially filled. Before operating at full speed, the excess grease in the bearing should be allowed to settle or escape into the housing cavity during a running-in period. At the end of the running-in period, the operating temperature will drop considerably indicating that the grease has been distributed in the bearing arrangement. See the generator manufacturer's specifications for more information on running-in loads and speeds.

2. Grease Selection

When selecting grease style and manufacturer for bearing lubrication, the base oil viscosity, consistency, operating temperature range, oil bleed rate, rust inhibiting properties, and the load carrying ability are the most important factors to be considered. Please refer to the generator manufacturer's recommendations for the proper grease type for a specific machine.

3. Lubricant Compatibility

If it becomes necessary to change from one grease to another, the compatibility of the greases should be considered.

CAUTION: If incompatible greases are mixed, the resulting consistency can change significantly and bearing damage due to lubricant leakage or lubricant hardening can result.

Greases having the same thickener and similar base oils can generally be mixed without any problems, e.g. a lithium thickener/mineral oil grease can generally be mixed with another lithium thickener/mineral oil grease. Also, some greases with different thickeners, e.g. calcium complex and lithium complex greases, can be mixed. However, it is generally good practice not to mix greases.

3. Lubricant Compatibility
(continued)

The only way to be absolutely certain about the compatibility of two different greases is to perform a compatibility test with the two specific greases in question. Often the lubricant manufacturers for common industrial greases have already performed these tests and they can provide those results if requested. Most preservatives used to protect bearings are compatible with the majority of rolling bearing greases with the possible exception of older style polyurea greases. Again, always check with the generator manufacturer before changing or mixing grease types or manufacturers.

4. Lubrication

In order for a bearing to be properly lubricated with grease, oil must bleed from the grease. The oil then coats the bearing components, but is gradually broken down by oxidation or lost by evaporation, centrifugal force, etc. Over time, the remainder of the grease will oxidize or the oil in the grease near the bearing will be depleted. At this point, re-lubrication is necessary to keep the bearing operating properly for its designed life. There are two critical factors to proper lubrication: the quantity of grease supplied and the frequency at which it is supplied. Ideally, re-lubrication should occur when the condition of the existing lubricant is still satisfactory. The lubrication interval depends on many related factors. These include bearing type and size, speed, operating temperature, grease type, space around the bearing, and the bearing environment. Please refer to the generator manufacturer's documentation for lubrication rates and quantities.

4.1. Manual Lubrication Procedure

There is probably a manufacturer's recommendation regarding the hours of operation before lubrication. It is recommended that this be considered a maximum parameter since the periodic maintenance of wind turbines is normally minimized due to the difficulties of access. Make sure all fittings are clean and free from contamination. If the exit port becomes clogged or if the grease hardens within the bearing housing, the excess grease can be pushed out of the generator and onto the exterior or, more importantly, into the interior of the generator, contaminating the windings. Dispense only the amount required. Do not overfill. Refer to the generator manufacturer's specifications regarding the quantity and frequency rate for lubrication of the bearings.

4.2. Automated Lubrication

Automated lubrication devices work by adding a measured amount of grease to the bearing housing. The influx of new grease pushes out older material through an exit port. Again, if the port becomes clogged or if the grease hardens within the generator, the excess grease can be pushed out of the housing and onto the exterior or, more importantly, into the interior of the generator, contaminating the windings. Operation of these devices is critical and they should be checked carefully during periodic turbine inspections. Auxiliary power should be available for a test run of the device to assure proper operation. Also, any grease in the automated device storage container where the oil has separated should be replaced.

5. Operating Temperature

Since grease aging is accelerated with increasing temperature, it is recommended to shorten the intervals when in increased operating temperature environments. The alternate also applies for lower temperatures and the lubrication interval may be extended at temperatures below 158°F (70°C) if the temperature is not so low as to prevent the grease from bleeding oil. In general, specialty greases are required for bearing temperatures in excess of 210°F (100°C). Again, consult the generator manufacturer for grease recommendations for extreme temperature conditions.

6. Vibration

Moderate vibration should not have a negative effect on grease life. But high vibration and shock levels, such as those in found in wind turbines, can cause the grease to separate more quickly, resulting in churning of the oils and thickener. In these cases the re-lubrication interval should be reduced. The overall importance of testing and controlling vibration is covered in another recommended practice.

7. Contamination

Contaminants have a very detrimental effect on the bearing surfaces. More frequent lubrication than indicated by the manufacturer’s recommended interval will reduce the negative effects of foreign particles on the grease while reducing the mechanical damaging effects. Fluid contaminants (water, oil, hydraulic fluids, etc.) also call for a reduced interval. Since there are no formulas to determine the frequency of lubrication because of contamination, experience is the best indicator the appropriate interval. It is generally accepted that the more frequent the lubrication the better. However, care should be taken to avoid overgreasing a bearing in an attempt to flush out contaminated grease. Using less grease on a more frequent basis rather than the full amount of grease each time is recommended. Excessive greasing without the ability to purge will cause higher operating temperatures because of churning.

Summary

This recommended practice is designed to provide basic information and techniques for proper lubrication of generator bearings as well as a troubleshooting guide to aid with maintenance and repair decisions. Proper care and lubrication, when required, will assure long, trouble free service life for these critical components.

Troubleshooting Guide

Bearings that are not operating properly usually exhibit identifiable symptoms. This section presents some useful hints to help identify the most common causes of these symptoms as well as practical solutions wherever possible. Depending on the degree of bearing damage, some symptoms may be misleading. To effectively troubleshoot bearing problems, it is necessary to analyze the symptoms according to those first observed in the applications. Symptoms of bearing trouble can usually be reduced to a few classifications, which are listed below.

Note: Troubleshooting information shown on these pages should be used as guidelines only.

1. Common Bearing Symptoms

- Excessive heat
- Excessive noise
- Excessive vibration
- Excessive shaft movement
- Excessive torque to rotate shaft

2. Excessive Heat

2.1. Lubrication

- Wrong type of lubricant
- Insufficient lubrication - too little grease
- Excessive lubrication - too much grease without a chance to purge

2.2. Insufficient Bearing Internal Clearance

- Wrong bearing internal clearance selection
- Excessive shaft interference fit or oversized shaft diameter
- Excessive housing interference fit or undersized housing bore diameter Excessive out-of-round condition of shaft or housing

2.3. Improper Bearing Loading

- Skidding rolling elements as a result of insufficient load
- Bearings are excessively preloaded as a result of adjustment
- Out-of-balance condition creating increased loading on bearing
- Linear misalignment of shaft relative to the housing
- Angular misalignment of shaft relative to the housing

2.4. Sealing Conditions

- Housing seals are too tight
- Multiple seals in housing
- Misalignment of housing seals
- Operating speed too high for contact seals in bearing
- Seals not properly lubricated
- Seals oriented in the wrong direction and not allowing grease purge

3. Excessive Noise

3.1. Metal-to-metal contact

- Oil film too thin for operating conditions
- Temperature too high

3.2. Insufficient quantity of lubrication

- Under lubricated bearing
- Leakage from worn or improper seals
- Leakage from incompatibility

3.3. Rolling elements skidding

- Inadequate loading to properly seat rolling elements
- Lubricant too stiff

3.4. Contamination

- Solid particle contamination entering the bearing and denting the rolling surfaces
- Solids left in the housing from manufacturing or previous bearing failures
- Liquid contamination reducing the lubricant viscosity
- Looseness
- Inner ring turning on shaft because of undersized or worn shaft
- Outer ring turning in housing because of oversized or worn housing bore

3.4. Contamination
(continued)

- Locknut is loose on the shaft or tapered sleeve
- Bearing not clamped securely against mating components
- Too much radial/axial internal clearance in bearings

3.5. Surface damage

- Rolling surfaces are dented from impact or shock loading
- Rolling surfaces are false-brinelled from static vibration
- Rolling surfaces are spalled from fatigue
- Rolling surfaces are spalled from surface initiated damage
- Static etching of rolling surface from chemical/liquid contamination
- Particle denting of rolling surfaces from solid contamination
- Fluting of rolling surfaces from electric arcing
- Pitting of rolling surfaces from moisture or electric current
- Wear from ineffective lubrication
- Smearing damage from rolling element skidding

3.6. Excessive Torque to Rotate Shaft

- Preloaded bearing
- Excessive shaft and housing fits
- Excessive out-of-round condition of shaft or housing
- Bearing is pinched in warped housing
- Wrong clearance selected for replacement bearing

3.7. Sealing Drag

- Housing seals are too tight or rubbing against another component
- Multiple seals in housing
- Misalignment of housing seals
- Seals not properly lubricated

3.8. Surface Damage

- Rolling surfaces are spalled from fatigue
- Rolling surfaces are spalled from surface initiated damage
- Fluting of rolling surfaces from electric arcing
- Shaft and/or housing shoulders are out of square
- Shaft shoulder too large and is rubbing against seals/shields